



Original communication

Applicability of the Demirjian method for dental assessment of southern Turkish children

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ABSTRACT

Age-related legal problems are especially common in underdeveloped parts of Turkey. In terms of civil and criminal law, the ages from 13 years to 18 years are critical in our country. Estimation of age is a very significant in aspect of accordance with laws. The aims of this study were to evaluate the applicability and accuracy of the Demirjian technique for assessing southern Turkish children; to analyze the sexual dimorphism of dental age in the studied groups; and to define the relationship between the dental age and the degree of mineralization in mandibular permanent tooth in southern Turkish children.

This study was performed using panoramic radiographs from 932 healthy southern Turkish children, 444 girls and 488 boys aged between 4 and 18 years. Statistical evaluations were performed using SPSS (Statistical Package for Social Sciences) for Windows 13.0 software. The mean difference between dental and chronological age was calculated for each age and sex group. The paired *t*-test was used to compare all data. The chi-square test was used for between-group comparisons of categorical variables. Continuous variables were tested for normality using the Kolmogorov–Smirnov test. Relationships between continuous variables were examined using Pearson's correlation coefficient. The same observer re-examined 700 teeth three months after the first examination. The results were evaluated with the intraclass correlation test and both measurements were statistically significantly similar with each other ($R = 0.982$, $p = 0.0001$). Dental age (DA) and chronological age (CA) were consistent for boys in the 16–16.9 age group and for girls in the 9–9.9 and 15–15.9 age groups.

From this study, we can conclude that dental age varies across ethnic populations. Additionally, dental maturation varies across different regions of the same country. Because Demirjian's standards are not suitable for all age groups of southern Turkish children, a new table is necessary for evaluating this population. Future studies using multi-ethnic population data are needed to establish the international applicability of Demirjian's method.

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1. Introduction

Dental age estimation is important in forensic sciences and for planning orthodontic and pedodontic treatment in dentistry.^{1,2} Age-related legal problems are especially common in underdeveloped parts of Turkey. In terms of civil and criminal law, the ages

from 13 years to 18 years are critical in our country. Applicable laws are dependent on age, as are criminal responsibility, legal capacity, and mental strength. Age also determines ability to attend school, retire, enter civil service, and obtain a driver's license, and is of vital importance in recruitment, especially in forensic medicine.^{1,3}

Dental age estimation helps in determining age of death of deceased children and provides useful information about physiological age when a birth date is unknown.² For juveniles and adolescents, age is determined using developmental indicators, such as skeletal maturity, body height and weight, sexual development, dental development, and eruption.⁴ Dental maturity is one of the

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most accurate, reliable, and fast indicators of age and is determined by evaluating dental development stage using radiographs.⁵ Tooth maturation and apical closure are less changeable than other developmental events, such as the appearance of bone ossification centers.⁶ Another indicator of dental age is the specific teeth present in the mouth.⁴ However, indicators are altered by local and systemic factors, such as hereditary, functional, environmental, sexual, nutritional, and metabolic factors.⁷

Many methods exist for estimating dental age based on degree of crown or root calcification and the shape of mineralized tooth parts observed in radiographic examinations.^{5,7} Currently, the most frequently used method is Demirjian's method, first described in 1973 in a large study of French–Canadian children.^{5,8} This technique evaluates mineralized dental tissues and the shape of the chamber of seven left permanent mandibular teeth from a panoramic radiograph and calculates dental age. Teeth are classified using an eight-stage system and given a mark indicating a developmental stage (A to H). Stage A represents initial signs of calcification at the superior level of the crypt, and H represents complete closure of the apical end of the root canal.

Over the years, Demirjian's method has been tested by many researchers on several ethnic groups and in geographical regions and cities within the same country^{1,2,9} to evaluate the reliability of Demirjian's system for assessing different groups.⁸

The aims of the present study were:

1. To evaluate the applicability and accuracy of Demirjian's technique for assessing southern Turkish children,
2. To analyze practicability of Demirjian's technique in different age groups for both genders.

2. Materials and methods

2.1. Materials

This retrospective study was performed using panoramic radiographs from 932 healthy southern Turkish children (444 girls and 488 boys, aged between 4 and 18 years). The radiographs were selected from patients who underwent treatment at the Faculty of Dentistry of Mustafa Kemal University in Hatay, Turkey. Only panoramic radiographs of adequate quality were selected. Children with gross pathology affecting growth and development of the teeth or with images which poorly visualized the mandibular teeth were excluded from the study. Ethics committee approval was not required for the present study.

2.2. Methods

The chronological age of each child was calculated by subtracting the date of the panoramic radiograph from the date of birth after converting both to a decimal age.

2.3. Statistical analysis

Statistical evaluations were performed using SPSS (Statistical Package for Social Sciences) for Windows 13.0 software. The mean difference between dental age and chronological age was calculated for each age and sex group. The paired *t*-test was used to compare all data. The chi-square test was used for between-group comparisons of categorical variables. Continuous variables were tested for normality using the Kolmogorov–Smirnov test. Relationships between continuous variables were examined using Pearson's correlation coefficient. A *p*-value of less than 0.05 was considered significant for all statistical data.

2.4. Repeatability

To assess the repeatability of our analysis, 100 panoramic radiographs were randomly selected three months after the first examination, and the same observer re-examined the radiographs. The percentage agreement of the two readings was computed by comparing the examinations of 700 teeth. The results were evaluated with the intraclass correlation test and both measurements were statistically significantly similar with each other ($R = 0.982$, $p = 0.0001$).

3. Results

The present study included 932 healthy southern Turkish children, 444 girls (47.6%) and 488 boys (52.4%). Age and gender distributions in the study population are shown in Table 1 and similar ($p = 0.686$). A strong linear correlation was detected between dental age and chronological age for male patients ($r^2 = 0.914$) and for female patients ($r^2 = 0.912$; Figs. 1 and 2). In Fig. 2, it is a scatter graph showing the correlation between the measured values of the dental age and chronological age in the female. It is specified by the *R* value ($R = 0.912/p = 0.0001$) there was a linear relationship between both values. The regression analysis has not been made since both of these values is a continuous variable and it was not affected in terms of gender. Differences between chronological ages (CA) and calculated dental ages (DA) according to the Demirjian method are presented in Table 2. The mean differences between the chronological and dental ages ranged from -1.20 to 1.36 years for females and from -1.02 to 1.69 years for males. The places marked at the Table 2, which are meant the one's *p* values bigger than 0.05, and indicating that the individuals in this age group have similar dental and chronological age, were made. Dental age (DA) and chronological age (CA) were consistent for boys in the 16–16.9 age group and for girls in the 9–9.9 and 15–15.9 age groups. Dental and chronological ages were significantly different for girls and boys in other age groups.

4. Discussion

Age prediction can be essential in cases of missing children, school continuance, and deaths occurring at a young age. Dental development stages can be useful in determining the ages of children.¹⁰ Although many methods are available for determining age, no universal system currently exists, as methods vary in accuracy when applied to different ethnic populations.¹ For estimating dental age, Demirjian formulated a method consisting of eight stages of tooth development in a study of French–Canadian children in 1973.

Table 1
Distribution of age and gender in the study population.

Age (years)	Male	Female	Total
4–4.9	10	6	16
5–5.9	23	18	41
6–6.9	28	26	54
7–7.9	35	36	71
8–8.9	33	43	76
9–9.9	47	41	88
10–10.9	50	44	94
11–11.9	50	42	92
12–12.9	47	39	86
13–13.9	41	25	66
14–14.9	32	27	59
15–15.9	25	36	61
16–16.9	32	26	58
17–17.9	35	35	70
Total	488	444	932

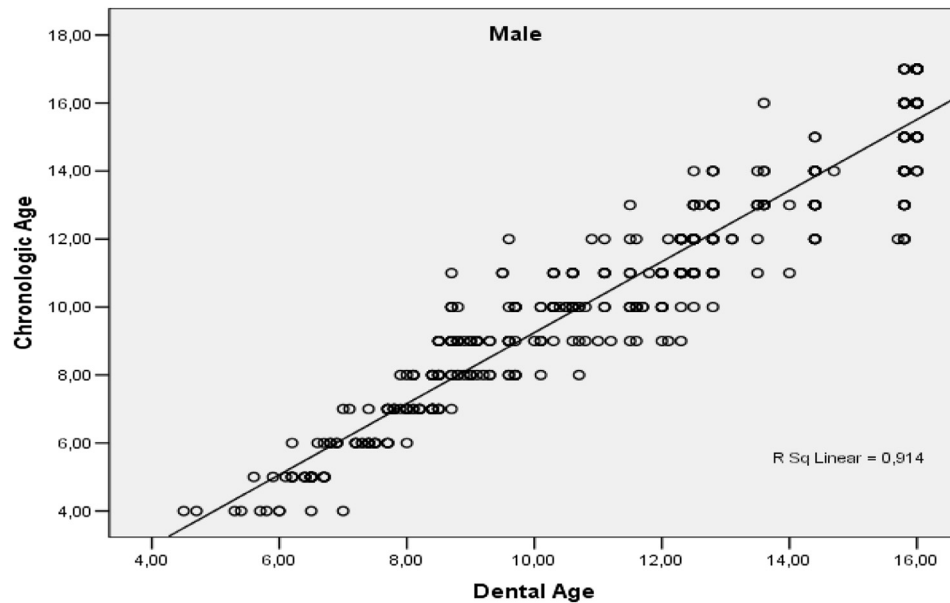


Fig. 1. Dental and chronologic ages for males.

Demirjian's method is one of the most well-known, simplest, and most practical of commonly employed methods.¹¹ Demirjian's method has been tested and applied in different populations for many years. Several past studies have shown that when Demirjian's standards are applied to other populations, the results are less accurate.^{3,9,12,13} Moreover, past studies have also demonstrated differences between geographical areas and cities within the same country.¹⁴ Studies by Celikoglu et al.¹⁵ and Tunc and Koyuturk⁹ were completed in different regions (Eastern and Northern Anatolia, respectively) of Turkey. In the current study, due to ethnic differences in population groups, the applicability of the method was tested using Demirjian's tooth development stages technique. The aim of this study was to evaluate the applicability of Demirjian's method for assessing the southern Turkish population and for comparing dental maturity between other Turkish regions and other populations. In the present study, we also emphasized and evaluated male and female differences.

In the present study, when compared with Demirjian's French-Canadian reference sample, the mean differences between the chronological and dental ages varied from –1.20 to 1.36 years for females and from –1.02 to 1.69 years for males. According to our results, in some groups, dental maturity was advanced, while in other groups, teeth were early matured. The results of our study also differed from those of Tunc and Koyuturk⁹ (northern Turkish children), Celikoglu et al.¹⁵ (southern Turkish children), and Mentis et al.¹⁶ (northwestern Turkish children). Our results show that dental maturity varies across different regions and even across different cities in the same country; thus, the applicability of Demirjian's method for assessing Turkish children is questionable.

Previous studies which assessed other populations using Demirjian's method revealed advanced dental maturity compared to the French-Canadian children. Advanced maturity has been demonstrated in populations such as the following: British children (boys, 0.73 years; girls, 0.51 years),¹⁷ Somalis (boys, 1.01 years; girls, 1.22

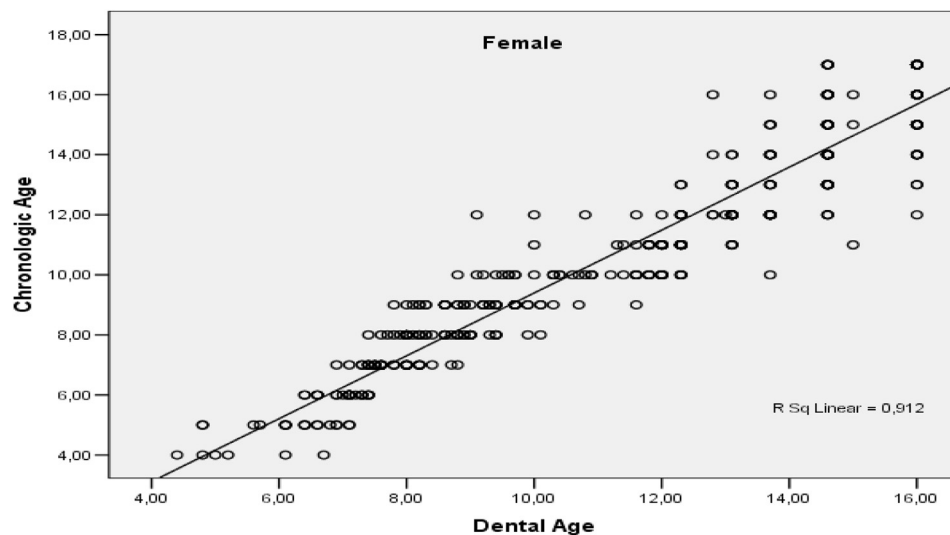


Fig. 2. Dental and chronologic ages for females.

Table 2

Differences between dental age determined by using the standard by Demirjian et al. and chronologic age.

Age groups (years)	Girls						Boys					
	n	DA-CA	S.D	Min	Max	p	n	DA-CA	S.D	Min	Max.	p
4–4.9	6	1.36	0.86	0.40	2.70	0.012	10	1.69	0.76	0.50	3.00	0.000
5–5.9	18	1.25	0.68	–0.20	2.10	0.000	23	1.38	0.26	0.60	1.70	0.000
6–6.9	26	1.04	0.29	0.40	1.40	0.000	28	1.29	0.40	0.20	2.00	0.000
7–7.9	36	0.73	0.42	–0.10	1.80	0.000	35	1.05	0.39	0.00	1.70	0.000
8–8.9	43	0.49	0.62	–0.60	2.10	0.000	33	0.90	0.65	–0.10	2.70	0.000
9–9.9	41	0.20	0.78	–1.20	2.60	0.097	47	0.61	1.69	–0.50	3.30	0.000
10–10.9	44	1.05	1.11	–1.20	3.70	0.000	50	0.69	0.99	–1.30	2.80	0.000
11–11.9	42	1.14	0.67	–1.00	4.00	0.000	50	0.83	1.06	–2.30	3.00	0.000
12–12.9	39	1.01	–2.90	2.90	4.00	0.000	47	0.86	1.31	–2.40	3.80	0.000
13–13.9	25	1.08	0.96	–0.70	3.00	0.000	41	0.72	1.14	–1.50	2.80	0.000
14–14.9	27	0.51	0.90	–1.20	2.00	0.007	32	0.84	1.14	–1.50	2.00	0.000
15–15.9	36	0.23	0.81	–1.30	1.00	0.091	25	0.80	0.43	–0.60	1.00	0.000
16–16.9	26	–0.73	0.89	–3.20	0.00	0.000	32	–0.13	0.42	–2.40	0.00	0.076
17–17.9	35	–1.20	0.49	–2.40	–1.00	0.000	35	–1.02	0.6	–1.20	–1.00	0.000

DA: Dental age CA: Chronologic age.

years), Caucasians (boys, 0.9 years; girls, 0.52 years),³ South Indians (males, 3.04 years; females, 2.82 years),¹ Dutch children (boys, 0.4 years; girls, 0.6 years),¹⁸ and Turkish children (boys, 0.36–1.43 years; girls, 0.50–1.44 years).⁹ Similar results in other populations may be explained by multiple factors, including cultural and ethnic differences between populations, socio-economic status, nutrition, and dietary habits. Gulati et al.¹⁹ reported that malnutrition can have an adverse effect on dental and skeletal maturation. Only healthy children with no systemic diseases, malnutrition, or skeletal or dental disorders were included in our study, and all children were of the same socio-economic status in order to minimize population differences.

Although Hagg and Mattson²⁰ reported that, especially in younger children, Demirjian's method shows a high degree of dependability and accuracy between dental and chronological age, our study's results do not support their findings across all age groups. In our study, of all of the groups, including males and females, the largest discrepancy between dental and chronological ages was found in the 4–4.9 age group. This finding is similar to those of Celikoglu et al.,¹⁵ Tunç and Koyuturk,⁹ and Mentis et al.¹⁶ Of all the groups, girls and boys in the 12–12.9 age group, girls in the 9–9.9 and 15–15.9 age groups, and boys in the 16–16.9 age group were the most consistent with Demirjian's standard charts. The precision of Demirjian's method, age distribution, sample size, statistical approach, and biological variation all affect the reliability of using the method on populations other than the standard population and a sample population.² In our study, these factors may have affected the results, and Demirjian's method should only be used for age estimation of Turkish females between the ages of 15 and 15.9 years and males between 16 and 16.9 years.

In several previous studies, differences have been reported in tooth development in females compared to their male counterparts. In Finnish children of all age groups (2.5 years and over),²¹ the tooth development rate was higher in females than in males. According to Krailassiri et al.,²² in Thailand, At the same skeletal maturity stage, the dental maturational patterns of male subjects were ahead of those of female subjects. Celikoglu et al.¹⁵ reported that Eastern Turkish girls showed advanced dental maturation in all age groups. In a study of Malaysian children, Nik Noriah Nik-Hussein et al.²³ reported results similar to those of Celikoglu et al.¹⁵ Most maturation parameters, such as height, sexual maturation, and skeletal development,^{5,20,24} occur earlier in girls. Although hormonal factors may influence differences between sexes in dental development,²⁵ strong supporting evidence has yet to be demonstrated. In this study, the results were significantly

different between genders. In the age groups ranging from 4 to 9.9 years, the boys were more advanced dentally than the girls. However, the girls had accelerated dental maturity compared to the boys in the age groups ranging from 10 to 17.9 years. Our findings do not support those of the abovementioned previous studies for children up to seven years of age.

Radiographs are indispensable tools and are usually used for dental age evaluation. Various types of radiographs have been used to research dental maturity. Since intraoral radiographs usually have image distortion, and panoramic radiographs are accessible and provide the ability to visualize all teeth, panoramic radiographs are the most accepted radiographic tool among the authors.²⁶

5. Conclusions

The maturity score of Demirjian's French-Canadian samples of the dental age was applicable at three age groups in the southern Turkish children. These groups were girls of the 9–9.9 years and 15–15.9 years age groups, and boys from the 16–16.9 years age group. From this study, we can conclude that the evaluation of dental age is dependent on the ethnic population. Additionally, dental maturation varies across different regions in the same country. Because Demirjian's standards are not suitable for all age groups of southern Turkish children, a new table is necessary for this population. Future studies using multi-ethnic population data are needed to establish the international applicability of Demirjian's method.

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Conflict of interest
No conflict of interest statement.

References

- Koshy S, Tandon S. Dental age assessment: the applicability of Demirjian's method in south Indian children. *Forensic Sci Int* 1998;**94**:73–85.
- Maber M, Liversidge HM, Hector MP. Accuracy of age estimation of radiographic methods using developing teeth. *Forensic Sci Int* 2006;**159**(Suppl. 1): S68–73.
- Willems G, Van Olmen A, Spiessens B, Carels C. Dental age estimation in Belgian children: Demirjian's technique revisited. *J Forensic Sci* 2001;**46**:893–5.

4. Eid RM, Simi R, Friggi MN, Fisberg M. Assessment of dental maturity of Brazilian children aged 6 to 14 years using Demirjian's method. *Int J Paediatr Dent/Br Paedod Soc Int Assoc Dent Child* 2002;**12**:423–8.
5. Demirjian A, Buschang PH, Tanguay R, Patterson DK. Interrelationships among measures of somatic, skeletal, dental, and sexual maturity. *Am J Orthod* 1985;**88**:433–8.
6. McKenna CJ, James H, Taylor JA, Townsend GC. Tooth development standards for South Australia. *Aust Dent J* 2002;**47**:223–7.
7. Liliequist B, Lundberg M. Skeletal and tooth development. A methodologic investigation. *Acta Radiol Diagn* 1971;**11**:97–112.
8. Demirjian A, Goldstein H, Tanner JM. A new system of dental age assessment. *Hum Biol* 1973;**45**:211–27.
9. Tunc ES, Koyuturk AE. Dental age assessment using Demirjian's method on northern Turkish children. *Forensic Sci Int* 2008;**175**:23–6.
10. Ritz-Timme S, Cattaneo C, Collins MJ, Waite ER, Schutz HW, Kaatsch HJ, et al. Age estimation: the state of the art in relation to the specific demands of forensic practise. *Int J Legal Med* 2000;**113**:129–36.
11. Garamendi PM, Landa MI, Ballesteros J, Solano MA. Reliability of the methods applied to assess age minority in living subjects around 18 years old. A survey on a Moroccan origin population. *Forensic Sci Int* 2005;**154**:3–12.
12. Chaillet N, Nystrom M, Kataja M, Demirjian A. Dental maturity curves in Finnish children: Demirjian's method revisited and polynomial functions for age estimation. *J Forensic Sci* 2004;**49**:1324–31.
13. Rozylo-Kalinowska I, Kiworkowa-Raczkowska E, Kalinowski P. Dental age in Central Poland. *Forensic Sci Int* 2008;**174**:207–16.
14. Nystrom M, Ranta R, Kataja M, Silvola H. Comparisons of dental maturity between the rural community of Kuhmo in northeastern Finland and the city of Helsinki. *Community Dent Oral Epidemiol* 1988;**16**:215–7.
15. Celikoglu M, Cantekin K, Ceylan I. Dental age assessment: the applicability of Demirjian method in eastern Turkish children. *J Forensic Sci* 2011;**56**(Suppl. 1): S220–2.
16. Menten A, Ergeneli S, Tanboga I. Applicability of Demirjian's standards to the Turkish children's dental age estimation. *J Marmara Univ Dent Fac*; 2000:63–8.
17. Liversidge HM, Speechly T, Hector MP. Dental maturation in British children: are Demirjian's standards applicable? *Int J Paediatr Dent/Br Paedod Soc Int Assoc Dent Child* 1999;**9**:263–9.
18. Leurs IH, Wattel E, Aartman IH, Etty E, Prahl-Andersen B. Dental age in Dutch children. *Eur J Orthod* 2005;**27**:309–14.
19. Gulati A, Taneja JR, Chopra SL, Madan S. Inter-relationship between dental, skeletal and chronological ages in well-nourished and mal-nourished children. *J Indian Soc Pedod Prev Dent* 1991;**8**:19–23.
20. Hagg U, Matsson L. Dental maturity as an indicator of chronological age: the accuracy and precision of three methods. *Eur J Orthod* 1985;**7**:25–34.
21. Nystrom M, Aine L, Peck L, Haavikko K, Kataja M. Dental maturity in Finns and the problem of missing teeth. *Acta odontol Scand* 2000;**58**:49–56.
22. Krailassiri S, Anuwongnukroh N, Dechkunakorn S. Relationships between dental calcification stages and skeletal maturity indicators in Thai individuals. *Angle Orthod* 2002;**72**:155–66.
23. Nik-Hussein NN, Kee KM, Gan P. Validity of Demirjian and Willems methods for dental age estimation for Malaysian children aged 5–15 years old. *Forensic Sci Int* 2011;**204**(208):e1–6.
24. Loevy HT, Goldberg AF. Shifts in tooth maturation patterns in non-French Canadian boys. *Int J Paediatr Dent/Br Paedod Soc Int Assoc Dent Child* 1999;**9**: 105–10.
25. Hilgers KK, Akridge M, Scheetz JP, Kinane DE. Childhood obesity and dental development. *Pediatr Dent* 2006;**28**:18–22.
26. Mani SA, Naing L, John J, Samsudin AR. Comparison of two methods of dental age estimation in 7–15-year-old Malays. *Int J Paediatr Dent/Br Paedod Soc Int Assoc Dent Child* 2008;**18**:380–8.